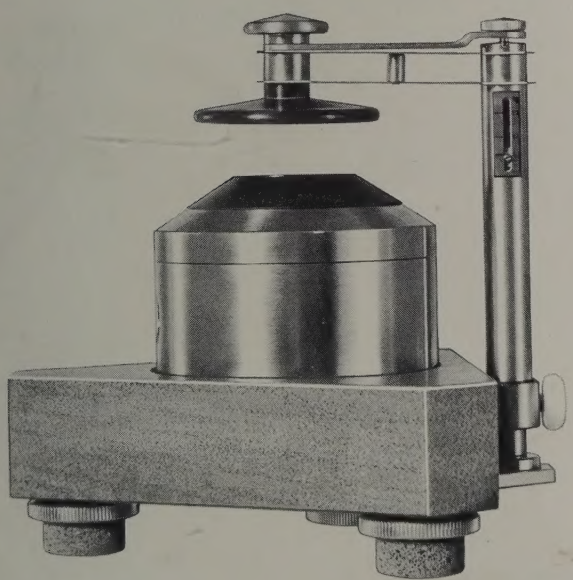
4153

Instruction Manual

Artificial Ear Type 4153



For electroacoustic measurements on supra-aural and circumaural headphones under well defined conditions. Has an acoustic impedance basically similar to that of the human ear. Fulfills the requirements of IEC Recommendation 318.

Brüel & Kjær

ERRATUM

Artificial Ear Type 4153
Instruction Manual (BE 0279-12), September 1986

Please note the following correction:

On pages 3 and 8 it is said that Sound Level Meters Types 2230 and 2233 can be used with the Artificial Ear. This is not the case as they cannot supply a microphone polarization voltage. Either Sound Level Meter Type 2231 or Sound Level Meter Type 2235 should be used instead, as these can supply the polarization voltage required.

Dept. 3. March 1987.

ARTIFICIAL EAR
TYPE 4153

Revision September 1986

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Artificial Ears

FEATURES:

- Conform to IEC and ANSI standards
- Complete reproducibility of results
- Well defined measuring conditions
- 2 cm^3 and 6 cm^3 couplers
- Adjustable clamping force

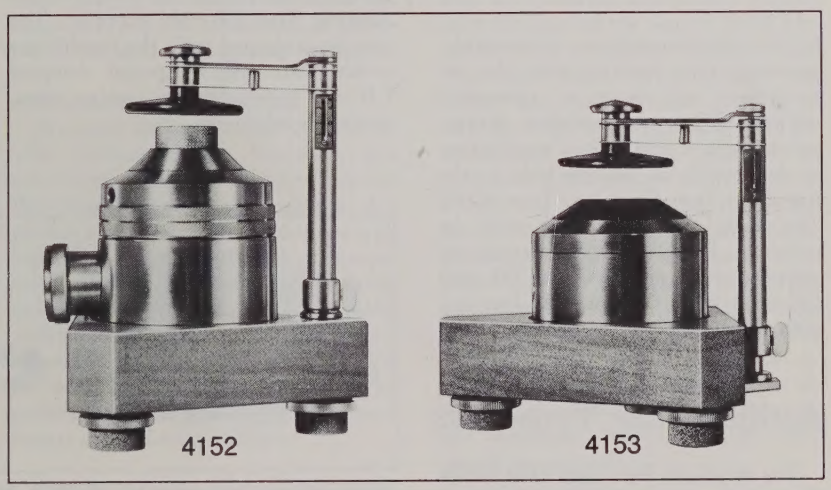
USES:

- Frequency response and sensitivity measurements on insert earphones and headphones
- Calibration of audiometers

The Artificial Ears Types 4152 and 4153 have been designed for measurements in the audiometric and related fields. They enable electroacoustical measurements on either insert earphones or headphones to be carried out under well defined acoustical conditions, which is of great importance for the comparability of different designs and the reproducibility of measurements.

The Artificial Ears Types 4152 and 4153 consist of an acoustic coupler, a main housing containing the sockets for the connection of a B & K condenser microphone and a base plate with a mechanism for clamping the object being tested.

The clamping mechanism is spring loaded and provides a force which can be adjusted from 2 N (approx. 0,2 kg) to 10 N (approx. 1 kg) as recommended by ANSI Standards, the actual force value being set on a scale engraved on the clamp holder. To minimise the effect of vibration during the measurements, each Artificial Ear is isolated from shock and vibration by means of three soft rubber feet.



Artificial Ear Type 4152

In the Artificial Ear Type 4152 the socket for mounting the measuring microphone permits use of a Brüel & Kjær 1″ Condenser Microphone Cartridge Type 4144 with associated Preamplifier Type 2639 or 2660 (Adaptor DB 0375 required). The couplers (see Fig. 1) supplied with the Artificial Ear consist of a 2 cm^3 Coupler in accordance with IEC R126 and ANSI S3.7–1973 for measurements on hearing aid earphones, and a 6 cm^3 Coupler DB 0909 which fulfils the requirements of the newer version of the American NBS 9A, ANSI S3.6–1969 and IEC R303 Coupler for measurements on headphones. If required, a special 6 cm^3 Coupler DB 0161 designed according to the requirements of ANSI S3.7–1973 Type 1 Coupler is available.

The 2 cm^3 Coupler may be used directly on the microphone with preamplifier without use of the main housing. In this manner an artificial ear is obtained which is very small and use-

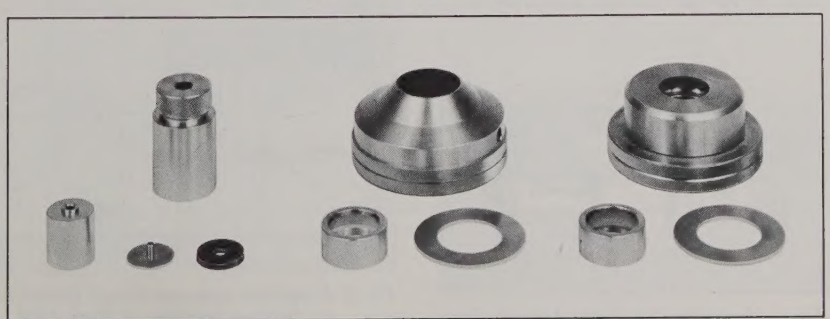


Fig. 1. Left to right: Couplers DB 0138, DB 0909 and DB 0161 with their respective adaptors and stop collars

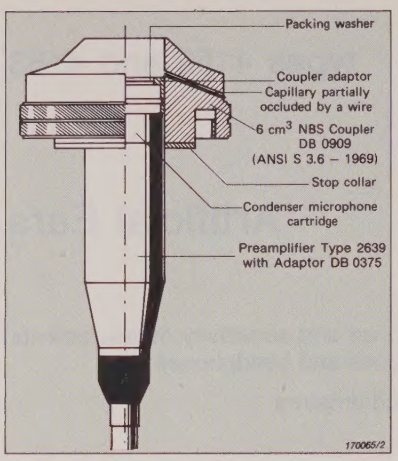

Packing washer
Coupler adaptor
Capillary partially occluded by a wire
6 cm³ NBS Coupler DB 0909 (ANSI S 3.6 – 1969)
Stop collar
Condenser microphone cartridge
Preamplifier Type 2639 with Adaptor DB 0375
170065/2

Fig. 2. Sketch showing how a 6 cm³ Coupler is mounted directly on a 1″ Condenser Microphone

ful for measurements on, for example, spectacle type hearing aids, the arrangement still being in agreement with the IEC recommendation. A typical example of this type of application is the testing of hearing aids in the Anechoic Test Chamber Type 4222. The 6 cm³ couplers may also be mounted directly on the microphone with the aid of a Stop Collar YO 2340 delivered with the couplers but not with the 4152. See Fig. 2.

Artificial Ear Type 4153

The Artificial Ear Type 4153 fulfils the requirements of IEC R 318 and has an acoustical impedance basically similar to that of the human ear. The acoustic coupler (Fig. 3) contains three volumes (V_1 = 2,5 cm³, V_2 = 1,8 cm³ and V_3 = 7,5 cm³) acoustically connected in parallel by means of a narrow annular slit and four parallel holes. The slit and the four holes act as an acoustic resistance of 6,5 × 10^6 Ns/m⁵ and 20 × 10^6 Ns/m⁵ respectively, while their acoustic inductances are 5 × 10^2 Ns²/m⁵ for the slit and 10^4 Ns²/m⁵ for the holes. An elec-

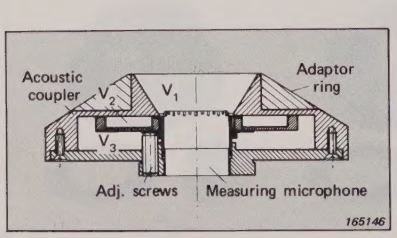


Fig. 3. Sectional view of the Acoustic Coupler used in the 4153

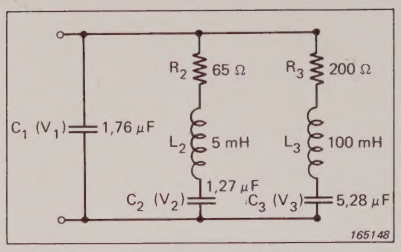


Fig. 4. The electrical equivalent circuit of the Type 4153

trical equivalent of the acoustic circuit is shown in Fig. 4.

The coupler fits the B & K ½″ Condenser Microphone Type 4134, and may be used with a Preamplifier Type 2639 (or 2660) mounted in the housing. The coupler also mounts directly on the preamplifiers by means of the Adaptor Ring DB 0742 supplied. The coupler is shaped to fit the headphone under test, and a special Adaptor DB 0843 is supplied for testing circumaural headphones.

For calibration purposes a well defined high acoustic impedance sound source is supplied with the Ear (Fig. 5). It consists of an Earcap YJ 0305 and an Adaptor AQ 0015 for a ½″ condenser microphone cartridge, which is used as sound transmitter.

Fig. 6 shows the pressure frequency response of the Artificial Ear Type 4153 measured with a ½″ Condenser Microphone Type 4134. The sound pressure is produced by the high impedance sound source, described above, which is fed from a constant ac voltage generator. The acoustical coupling between the transmitting microphone and the Artificial Ear is established by pressing the Earcap against the Ear.

Fig. 6 also shows the pressure frequency response of the Artificial Ear Type 4152 with the 6 cm³ Coupler DB 0909 measured with a 1″ Condenser Microphone Type 4144. The sound source is the same as above.

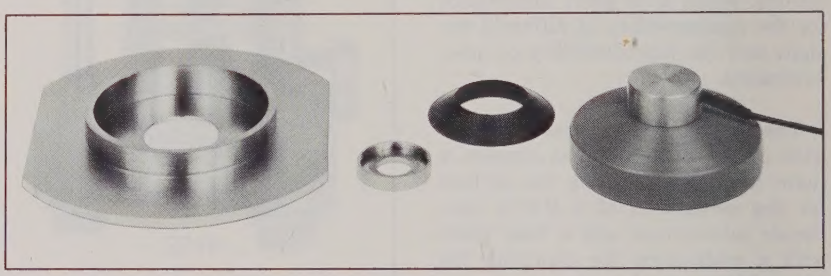


Fig. 5. Left to right: Adaptor DB 0843, Adaptor Ring DB 0742, Adaptor YJ 0304 and Earcap YJ 0305 with Adaptor AQ 0015 mounted

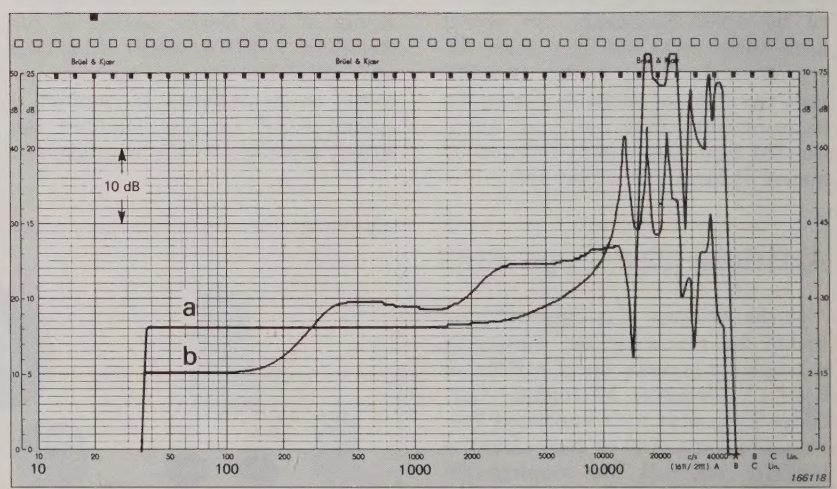


Fig. 6. Frequency response curves for the Artificial Ears
a) pressure response of Type 4152
b) pressure response of Type 4153

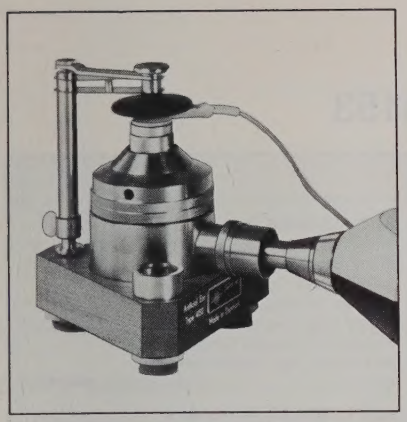


Fig. 7. Artificial Ear Type 4152 and Sound Level Meter in combination

Measuring Instruments

Measuring Amplifier Type 2609, 2610 or 2636 can be used as the indicating instrument for the Artificial Ears. If frequency analysis, distortion measurements or measurements at very low levels are required one of the B & K range of Frequency Analyzers or the B & K Audio Test Station Type 2118 which is a combined signal generator, response analyzer and pen plotter can be used. For a more portable system a Sound Level Meter Type 2230 or 2233 plus Filter Set Type 1624 or 1625 can be employed as the indicating instrument with the Artificial Ear Type 4152. An Adaptor DB 0962 is provided for connecting the 4152 to the input of the Sound Level Meter and the microphone preamplifier of the Audio Test Station. For use of the Audio Test Station with the 4153, no adaptor is required.

Calibration

A measuring set-up with one of the Artificial Ears Type 4152 or 4153 can easily be calibrated with a Pistonphone Type 4220 to an accuracy of within ± 0,2 dB at 250 Hz or with a Sound Level Calibrator Type 4230, to an accuracy of within ± 0,25 dB at 1000 Hz.

Examples of Use

Frequency Response Recording

Fig. 8 shows a measuring set-up that allows the frequency response of a headphone to be recorded automatically. The Sine Generator provides the necessary ac current for the headphone. If required, the current delivered to the headphone may be kept constant by connecting a resistor in series with the headphone and using the voltage drop across this resistor to control the compressor circuit of the Sine Generator. The output from the microphone in the Artificial Ear Type 4153 is fed to the Measuring Amplifier and recorded by means of the Level Recorder. A mechanical coupling between the Generator and the Level Recorder allows frequency response curves to be recorded directly on frequency calibrated paper on the Level Recorder. For suppression of background noise when measuring at low levels the Heterodyne Slave Filter Type 2020 or the Band Pass Filter Set Type 1617 can be connected as external filters to the Measuring Amplifier.

Audiometer Calibration

Accurate audiometers have become vital instruments in hospitals and schools as well as in industry because they allow full checks to be made of a person's hearing, and possible hearing loss. The accuracy of such measurements, however, depends to a great extent on the accuracy with which the audiometer is calibrated. Litigation concerning hearing loss claims calls for audiometric tests supported by calibration data which will withstand expert critical examination.

Only a complete acoustical calibration of the audiometer at all hearing levels, with the calibration referenced to an incontestable acoustic source, can fulfil such stringent requirements. Also, since to move an audiometer may upset its calibration, the calibration equipment itself must be made portable.

A suitable calibration arrangement which would meet these demands would consist of a Sound Level Meter Type 2230 or 2233, a Pistonphone Type 4220 and an Artificial Ear Type 4152.

To minimise the effects of ambient noise and structure-borne vibrations on low level acoustic calibration of audiometers, the Sound Level Meter should be fitted with one of the Filter Sets Types 1624 or 1625. Both Filter Sets are portable and mount directly onto the base of the Sound Level Meter to form a compact integral unit. Type 1624 has 10 octave filters with centre frequencies from 31,5 Hz to 16 kHz, while Type 1625 has 31 third-octave and overlapping octave filters with centre frequencies from 20 Hz to 20 kHz. By first calibrating the Sound Level Meter by means of the Pistonphone and then using the Sound Level Meter together with the Artificial Ear for the actual Audiometer calibration, an accurate, easy to operate and fully portable audiometer calibrator is obtained. For measurements on bone vibrators, the Product Data sheet for the Artificial Mastoid Type 4930 should be consulted.

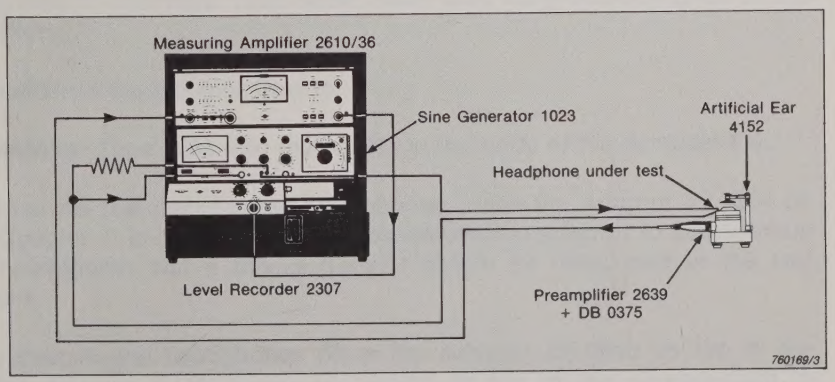


Fig. 8. Measuring set-up for automatic recording of the frequency response of a headphone under constant input current conditions

Specifications 4152 and 4153

TYPE 4152

MEASURING MICROPHONE:*
Type 4144: 1″ Condenser Microphone

PREAMPLIFIER:*
Microphone Preamplifier Type 2639 S (includes Adaptor DB 0375)

COUPLERS AVAILABLE:
DB 0138: 2 cm^3 (supplied)
DB 0909: 6 cm^3 (supplied)
DB 0161: 6 cm^3

MAX. FORCE APPLIED TO THE TOP OF ACOUSTIC COUPLER:
10 N (1 kg)

DIMENSIONS:
Height: 104 mm (4,1 in)
Max. diameter: 123 mm (4,85 in)

WEIGHT:
1,5 kg (3,3 lb)

ACCESSORIES INCLUDED:
2 cm^3 coupler ..... DB 0138
6 cm^3 coupler ..... DB 0909
(without base ring YO 2340)
Coupler adaptor ring ..... DB 0111
Guard ring adaptor ..... DB 1021
Adaptor for Sound Level Meter and Audio Test Station preamplifier ..... DB 0962

ACCESSORIES AVAILABLE:
6cm^3 Coupler ..... DB 0161
(Conforms to ANSI S3.7-1973)

TYPE 4153

MEASURING MICROPHONE:*
Type 4134: 1/2″ Condenser Microphone

PREAMPLIFIER:*
Microphone Preamplifier Type 2639 (or 2660)

DIMENSIONS:
Height: 104 mm (4,1 in)
Max. diameter: 123 mm (4,85 in)

WEIGHT:
2,2 kg (4,82 lb)

ACCESSORIES INCLUDED:
Adaptor ..... DB 0742
Adaptor ..... DB 0843
Adaptor ..... AQ 0015
Earcap ..... YJ 0305

COUPLER VOLUMES:

	Volume	Acoustic Capacitance
V_1	2,5 cm^3 ± 1%	17,6 × 10^{-12} m^5/N
V_2	1,8 cm^3 ± 1%	12,7 × 10^{-12} m^5/N
V_3	7,5 cm^3 ± 1%	52,8 × 10^{-12} m^5/N

T01157GB0

CONNECTIONS BETWEEN CAVITIES:

	Acoustic Resistance	Acoustic Inductance
Annular slit:	6,5 × 10^6 Ns/m^5	5 × 10^2 Ns^2/m^5
Four parallel holes:	20 × 10^6 Ns/m^5	10^4 Ns^2/m^5

T01265GB0

* to be ordered separately

2. OPERATION

2.1. PRELIMINARY

A sectional view of the Artificial Ear Type 4153 is shown in Fig. 2.1.

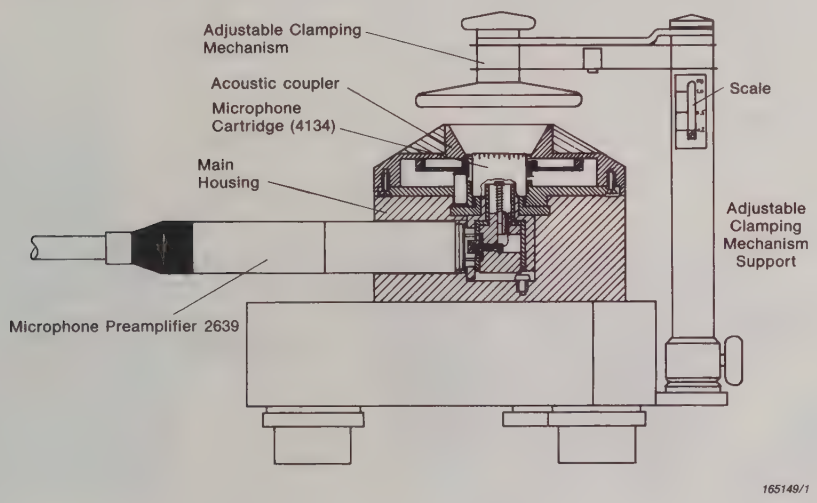


Fig. 2.1. Sectional view of the Artificial Ear Type 4153

To prepare the Artificial Ear for use proceed as follows:

1. Unscrew the Coupler.

2. Mount the Microphone Cartridge Type 4134, fitted with its protection grid, to the microphone socket.

3. Replace the Coupler on the Coupler Socket.

4. Screw the Preamplifier Type 2639 into the socket in the body of the Artificial Ear.

5. a. For testing normal (i.e. supra-aural) headphones, place the Adaptor YJ 0304 on top of the Coupler. It is possible to invert or remove the Adaptor to accomodate particular headphones but if this is done it should be mentioned in the test specifications.

   b. For testing circumaural headphones place the Adaptor DB 0843 on top of the Coupler. The Adaptor YJ 0304 may be placed on top of this arrangement to simulate the human pinna. The Adaptor YJ 0304 may be either upright or inverted and the orientation chosen should be mentioned in the test specifications. The clamping mechanism cannot be used with the Adaptor DB 0843.

6. Place the headphone to be tested on top of the Artificial Ear.

7. If one wishes to apply a force to the headphone proceed as follows:

   a. Supra-aural headphones: mount the clamping mechanism on the base of the Artifical Ear then adjust the height of the mechanism until the desired force is indicated on the engraved scale.

   b. Circumaural headphones: use weights to provide the desired force but do not exceed 10 N (1 kg force).

8. Connect a generator to the headphone and an indicating instrument to the preamplifier.

The Artificial Ear is now ready for use.

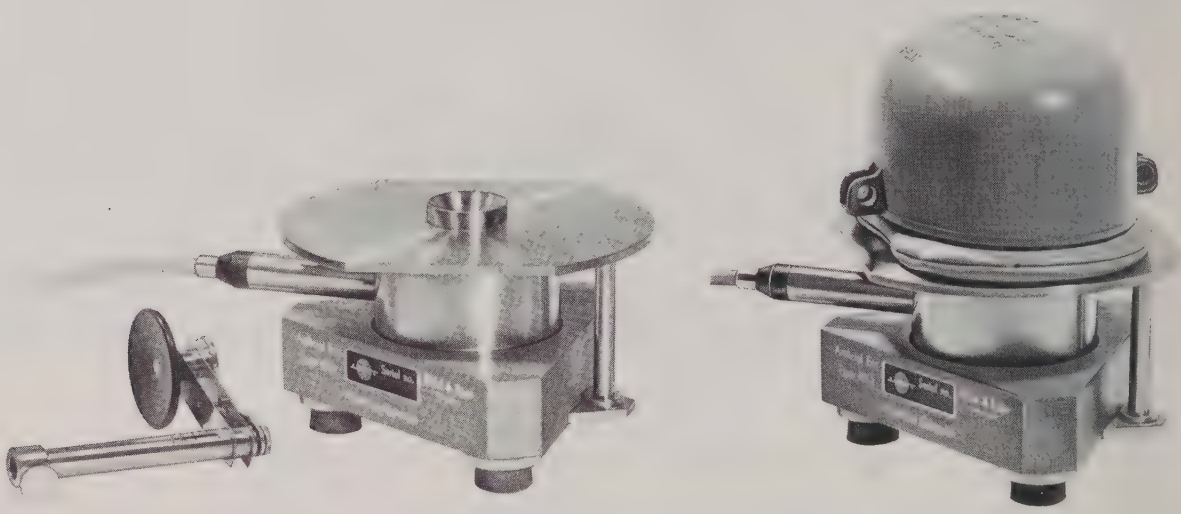


Fig. 2.2. a) Adaptor DB 0843 mounted on the Artificial Ear (the clamping mechanism and the Adaptor YJ 0304 have been removed)
b) A circumaural sound damping device mounted on the Artificial Ear

2.2. OPERATION OF A COMPLETE ARRANGEMENT FOR THE TESTING OF HEADPHONES

Fig. 2.3. shows a typical arrangement used to test the frequency characteristics of earphones using the Artificial Ear Type 4153.

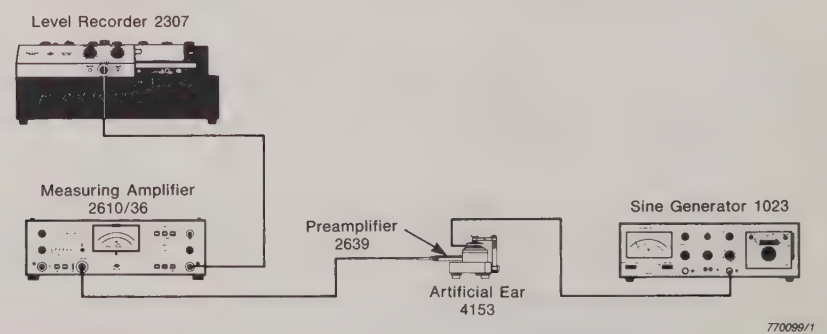


Fig. 2.3. Typical measuring arrangement for the checking of headphone characteristics

The procedure is as follows:

Adjustment of Sine Generator Type 1023

1. Carry out all the preliminary adjustments as explained in the Operations section of the 1023 Instruction Manual.

2. The Generator controls are then set to the following positions:

GENERATOR	"On"
REF. SIGNAL	"Off"
SWEEP CONTROL	"Manual/Ext. Mech." and "Log."
COMPRESSOR SPEED	"Off"
MODULATION FREQUENCY	"Mod. Off"
COUNTING TIME	"0,1 s"
OUTPUT ATTENUATOR	"Load"
POWER	"On"

3. Connect the load to the input terminals of the earphone under test.

Adjustment of Measuring Amplifier Type 2610

1. Carry out all the preliminary adjustments as described in the Operation section of the 2610 Instruction Manual.

2. Set the Amplifier controls as follows:

INPUT	"Preamp."
INPUT GAIN	"Cal."
OUTPUT SECTION GAIN	"1"
DETECTOR	"RMS" "Normal"
AVERAGING TIME	"Fast"
FILTERS	22,4 Hz:"On". Ext:"Off". A:"Off"
POWER	"On"

3. Assemble the Artifical Ear as described previously and select the coupler suitable for the headphone to be tested.

4. Connect the Condenser Microphone of the Artificial Ear to the Measuring Amplifier via the "Preamp." input.

Adjustment of Level Recorder 2307

1. Carry out the preliminary adjustments as described in the 2307 Instruction Manual.

2. Insert a 50 dB potentiometer in the 2307.

3. Set the controls as follows:

POTENTIOMETER RANGE	"50 dB"
RECTIFIER RESPONSE	"RMS"
LOWER LIMITING FREQUENCY	"20 Hz"
POWER and MOTOR	"On"
WRITING SPEED	"315 mm/s"
PAPER SPEED	"3 mm/s"
PAPER DRIVE FUNCTION	"Automatic Stop F"

4. Connect the mechanical drive cable to Drive Shaft I.

5. Use B&K Recording Paper QP 1124 (100 mm width).

6. By means of the knurled wheel on the front panel of the 2307 adjust the paper until the Recorder Pen is aligned with the 20 Hz mark on the pre-calibrated paper.

Calibration

Either the Pistonphone 4220 or the Sound Level Calibrator 4230 may be used to calibrate the system.

The procedure is as follows:

1. Set the INPUT SECTION GAIN of the 2610 so that 120 dB (for Pistonphone calibration) or 90 dB (for Sound Level Calibrator calibration) is indicated on the meter scale by the range indicator lamps of the meter.

2. Remove the Coupler from the Artificial Ear and then fit the Pistonphone (or Sound Level Calibrator) snugly over the microphone.

3. Using the Pistonphone the meter should read 124 dB (94 dB for the Sound Level Calibrator). If it does not, adjust the SENS. potentiometer beside the INPUT socket being used until the correct meter deflection is obtained.

4. Using the INPUT POTENTIOMETER and INPUT ATTENUATOR of the Level Recorder, the position of the pen can be adjusted so that the recording paper can be conveniently calibrated.

5. Reassemble the Artificial Ear.

Frequency Sweep

1. Set the frequency of the Sine Generator to 20 Hz.

2. Lower the pen of the Level Recorder onto the paper.

3. Press the Paper Drive "Start" button and the frequency characteristic will be recorded up to 1000 Hz where the Generator will automatically halt the sweep. To continue the sweep up to 20 000 Hz press the Paper Drive "Start" button again.

Headphones are usually tested under constant voltage conditions as described above. However by connecting a resistor in series with the earphone and using the voltage drop across the resistor to control the compressor circuit of the Sine Generator constant current conditions can be obtained for the test.

2.3. USE WITH THE PRECISION SOUND LEVEL METER

The Precision Sound Level Meter (Types 2230 or 2233) can serve both as an amplifier and as an indicating meter to the Artificial Ear. The addition of an Octave (Type 1624) or a Third Octave and Octave (Type 1625) Filter Set to this arrangement forms a compact combination for audiometer calibration. (See the relevant Instruction Manual for the operation of the Sound Level Meter).

2.4. HIGH ACOUSTIC IMPEDANCE SOUND SOURCE

To enable the user of the Artificial Ear to make precise and reproducible measurements for comparison with other couplers and ears, a well defined, high impedance sound source is supplied with Type 4153. It consists of an Earcap YJ 0305 and an Adaptor AQ 0015 for a 1/2″ microphone cartridge which is used as a sound source. Fig. 2.4 shows a sectional view of the Sound Source.

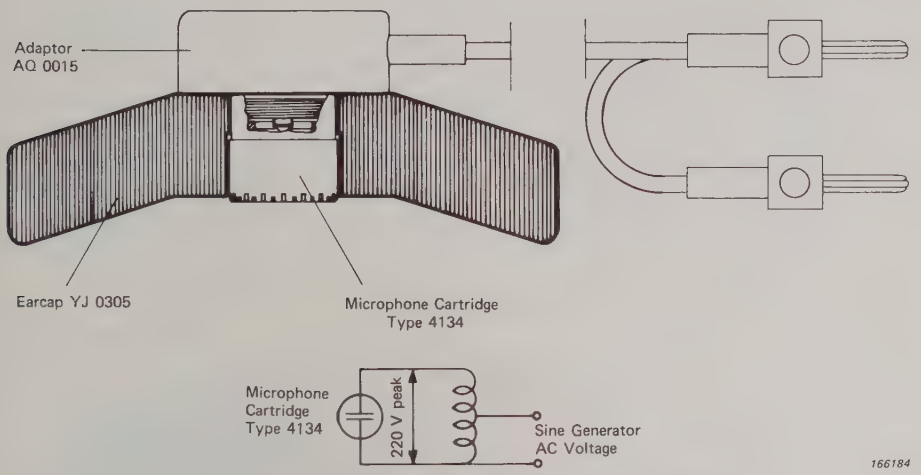


Fig. 2.4. Sectional view of the High Acoustic Impedance Sound Source

The microphone is usually used with a polarization voltage of 200 V and under these conditions the maximum r.m.s. alternating voltage that may be applied to the microphone is 5,7 V.

However, when the microphone cartridge is used without a polarising voltage a much higher alternating voltage may be employed producing considerably higher sound pressure levels but with a frequency of twice that of the alternating voltage supplied to the cartridge. The alternating voltage, e_1, should not be chosen to be higher than 220 V peak for the Microphone Cartridge Type 4134. In Fig. 2.5 the sound pressure which the microphone, used as a sound source, will produce in a very small chamber is shown. The data for the curve was measured with an electrostatic actuator and shows the frequency response of the cartridge used as a microphone but it represents exactly the sound pressure transmitted into a capacitive acoustical impedance.

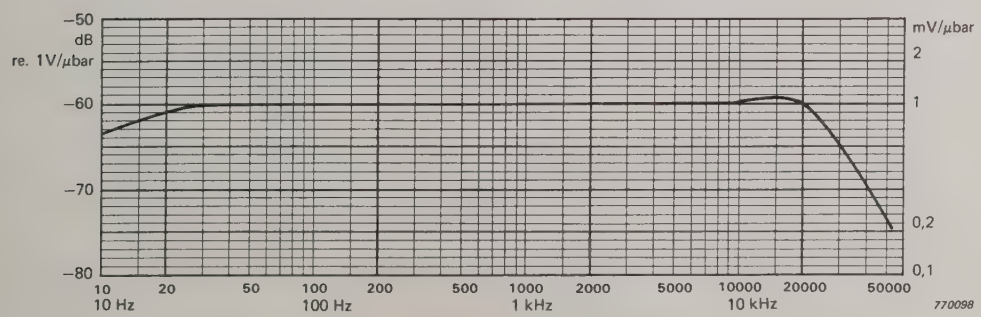


Fig. 2.5. Pressure frequency response of the B&K 1/2″ Condenser Microphone Type 4134

2.5. MEASUREMENT OF THE IMPEDANCE OF THE HUMAN EAR

An interesting application of the Earcap YJ 0305 is the measurement of the pressure response of the human ear. The arrangement for such a measurement is shown in Fig. 2.6. (The procedure is described in detail in B&K Technical Review No. 4/1961). The Earcap, which is made of acoustically hard material, is placed against the human ear. To avoid any leakage the join between the ear and Earcap is sealed with vaseline.

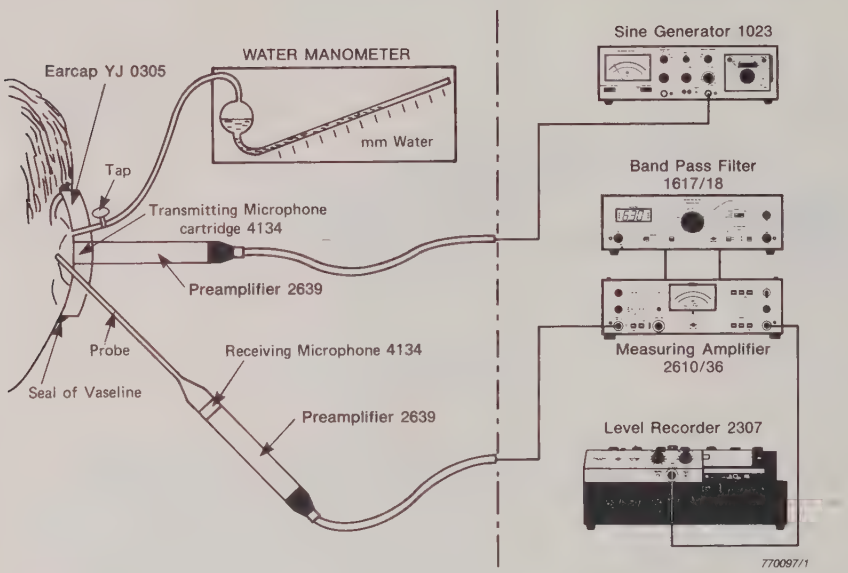


Fig. 2.6. Arrangement for measuring the sound pressure at the entrance of the human ear canal using a 1/2″ condenser microphone as a transmitter and a probe microphone as a receiver

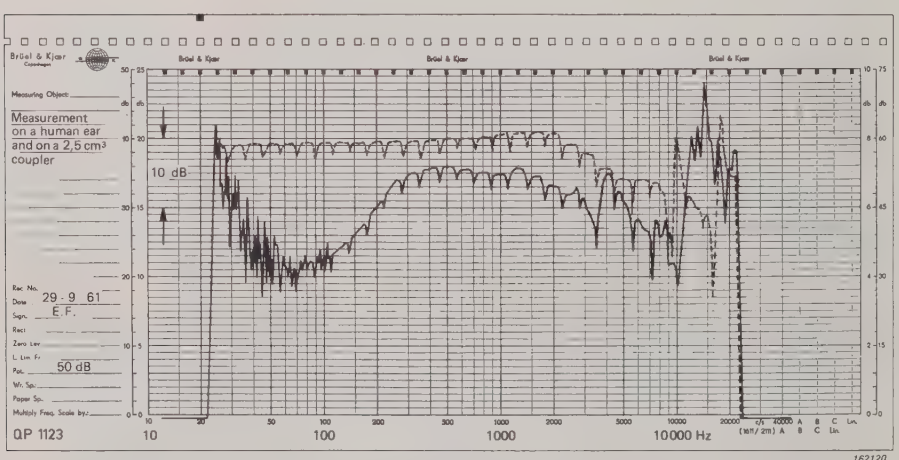


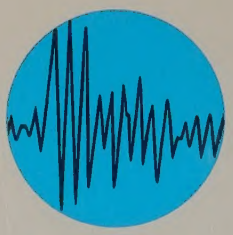
Fig. 2.7 Typical recording obtained from measurements on a human ear (solid line) and on a simple 2,5 cm³ Coupler (dotted line)

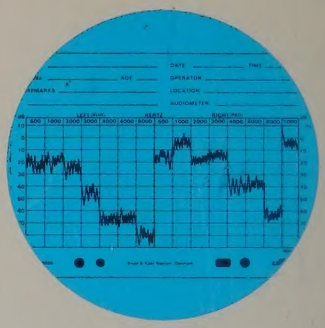
To enable this seal to be checked, a tube is led through a hole drilled in the Earcap to a water manometer. A slight overpressure of a few mm of water should be maintained. The tube must be closed during the measurement in order to avoid the effects of its compliance. A 1/2″ transmitting condenser microphone is mounted in the centre of the Earcap and is driven with a constant alternating voltage from the Sine Generator Type 1023. The microphone used as a sound source will give a constant volume displacement within the frequency range 20 Hz–20 kHz. The frequency doubling produced by using the microphone as a transmitter means that if one wishes to make measurements from, say, 20 Hz to 20 kHz then the sine generator employed should cover the frequency range 10 Hz to 10 kHz. The signal from the receiving microphone is fed to the input of a frequency analyser. The receiving probe microphone should be calibrated before use and passed through the second hole in the Earcap and positioned so that it measures the sound pressure at a point very close to the transmitting microphone. The frequency analyser, which consists of a measuring amplifier and a set of filters, measures the signal selectively in third octave bands thus minimising the effect of ambient noise and pressure variations due to the movements of the person being tested. A typical pressure response curve is shown in Fig. 2.7 together with a reference recording of the sound pressure produced in a simple 2,5 cm^3 coupler consisting of one cavity.

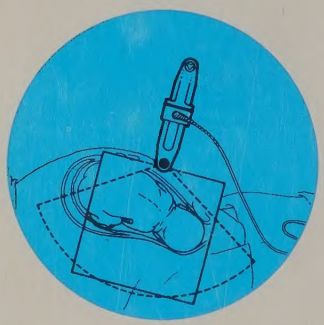
2.6. INFLUENCE OF VIBRATION

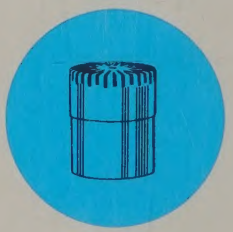
When the Artificial Ear is used to test headphones care should be taken to minimize the effects of extraneous vibrations on the measurements. Although the Ear is isolated from vibration by three soft rubber feet, large vibrations may influence the test results. Headphones possessing soft rubber pads, designed to fit snugly to the listener's head, may prove to be particularly difficult to test because they may act as "accelerometers".

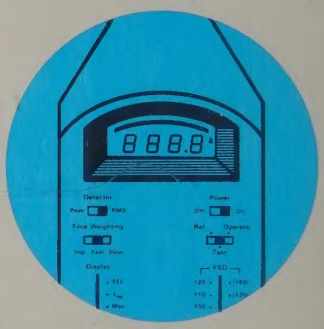
There are, however, several ways of overcoming the problem of intrusive vibration, such as mounting the measuring system on foam rubber, using a selective measuring arrangement and mounting the Ear in horizontal position to minimize the piston action of the headphone mass.

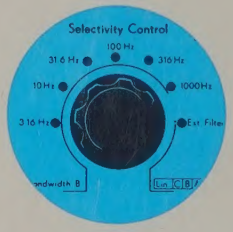


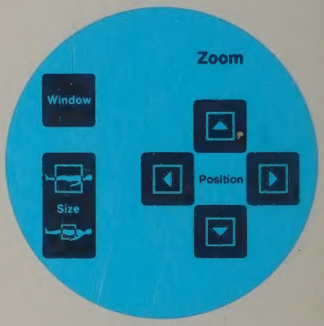


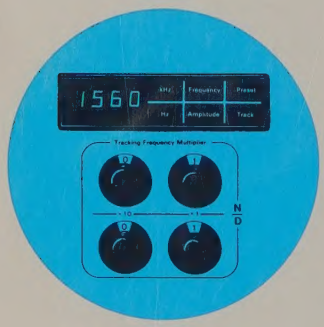


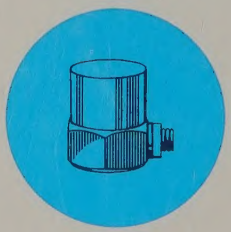


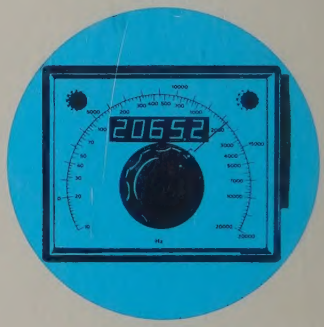


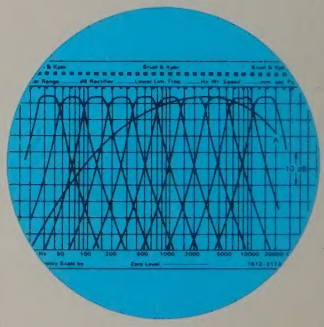


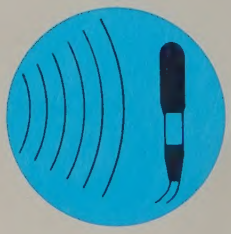












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